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PRELIMINARY PROPOSAL FOR SATELLITE LAUNCHER USING CLUSTERED SADAM ROCKETS

1. INTRODUCTION

During the recent hostilities, Iraqi Military Industries reverse engineered the SCUD-B rocket while at the same time developing improved versions. Thus there are available in Iraq three types of single stage, liquid rocket motors whose characteristics are summarized in Table 1.

The liquid fuel consists of the hypergolic combination of hydrazine N_2H_4 and nitric oxide, HNO_3 in a mixture ratio to give the specific impulse as listed in Table 1. Each rocket carries its own stabilizing, guidance and control package. Launched vertically, the rocket is tilted over to an approximate 45 degree path angle as it rises through the lower atmosphere.

The problem has been studied of the feasibility of clustering and staging these rockets in such a manner as to achieve worthwhile orbital payloads. The results of the study with discussion are presented in this report.

2. THERMO-CHEMISTRY OF COMBUSTION

At the time of conduct of this study, the exact nature of the fuel and mixture ratios was unknown. Using normal thermo-chemical combustion calculations, assuming an average between the equilibrium and frozen case, the thrust and specific

impulse characteristics of this and similarly fueled systems was studied. Particularly a comparison was made with the 1966 HARP Aerojet General system, (Ref. 1) which used as fuel a mixture of 86% monomethyl hydrazine ($CH_3.NH.NH_2$) and 14% hydrazine N_2H_4 and as an oxidizer a mixture of 71% HNO_3 (nitric acid) with 29% NO_2 (red fuming nitric acid). Aerojet General designed the HARP system about their standard service rockets. Using a 5:1 nozzle area ratio, and a chamber pressure of 500 psi, the specific impulse for this system was 250 seconds (sea level) and 292 seconds (in vacuum).

The low specific impulse achieved on the motors listed in Table 1 is difficult to understand. While normal losses may reduce the efficiency, the maximum reduction should lie between 5% and 10%. Various factors influence the efficiency. Besides the mechanical losses must be included :

i) Deviations from the optimum mixing ratio.
ii) Uneven and/or incomplete combustion in the chamber (combustion chamber design plus fuel-oxidizer mixing)
iii) Nozzle losses

These aspects are discussed in more detail in Appendix 1.

Since it is felt that improvement in the specific impulse can be achieved, the studies of clustered rocket performance were conducted using the specific impulses given in Table 1 and repeated using a value of vacuum specific impulse for all motors of 292 seconds, corresponding to that achieved during the HARP project.

TABLE 1
ASSUMED MISSILE CHARACTERISTICS

	SCUD B	SADAM 80	SADAM 100
1. All-up, less warhead mass, kg	4860	5694	7052
2. Fuel mass, kg	3786	4769	5925
3. Guidance & Control Module, kg	198	198	198
4. Fins & attachment, kg	120	120	120
5. Case Weight, kg	756	835	929
6. Gross Mass Fraction	0.779	0.838	0.840
7. Mass Fraction less 3 + 4	0.833	0.887	0.880
8. Nominal Burn Time (secs)	63	80	100
9. Missile Outside Diameter, m	0.88	0.88	0.88
10. Nozzle exit diameter, m	0.3988	0.3988	0.3988
11. Nozzle Throat Diameter, m	0.126	0.126	0.126
12. Mass flow, $\frac{dm}{dt}$, kg/sec	57.83	57.83	57.83
13. Fuel consumed in nominal burn time, kg	3642	4626	5783
14. Sea Level Thrust, kg F	13380	13380	13380
15. I_{S_p} in vacuum, sec	253.7	253.7	253.7
16. Length of missile body excluding g & c module, m	7.154	8.654	10.419

3. CLUSTERED ROCKET COMBINATIONS

Within the time available for these studies, optimized system studies were not possible. Rather the combinations evaluated through orbital trajectory studies were selected to bracket the optimum.

The first stage systems studied consisted of 4, 5 and 6 Sadam 80 rockets with the second stage being one and two Sadam 100 rockets respectively. The use of two Sadam 100 rockets for the second stage was studied to show that it was deviating away from the optimum and had less performance (payload in orbit) than the single second stage rocket case.

The layout of the various clustered rocket configurations is shown in Figure 1. Studies were conducted using the specific impulse values of Table 1 for the first and second stages, as well as the higher value discussed previously.

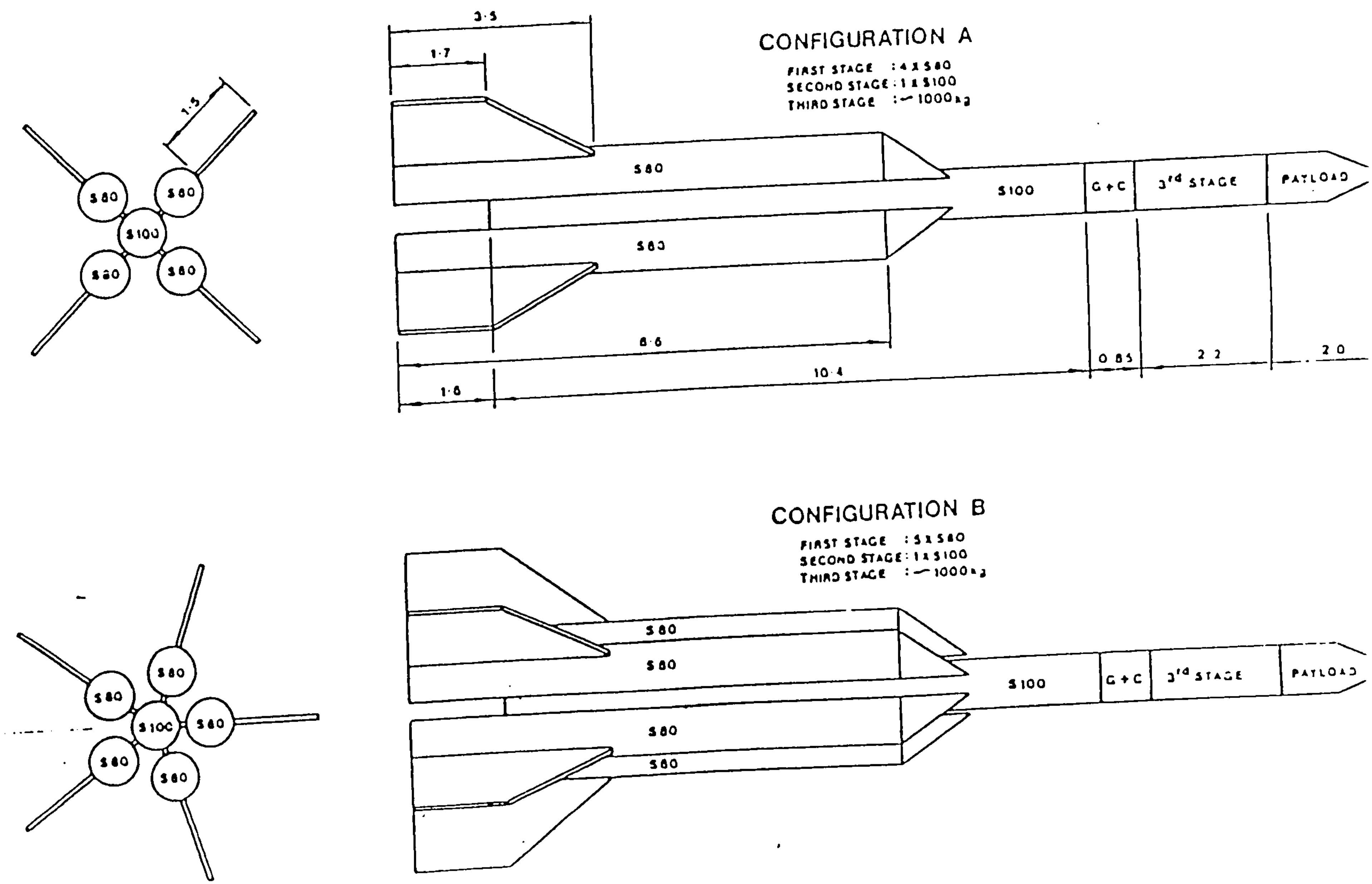
The third stage system was considered always to have the higher (292 second) specific impulse and a mass fraction of 0.85. The size of the third stage was gauged for optimum by determining the effective payload in orbit as this stage size was varied.

As shown in Figure 1, the cluster configurations considered may be considered in the following categories :

Configuration A

This consists of four Sadam 80 rockets as a first stage, clustered about a Sadam 100 rockets as the second stage. The third stage is a specially designed system to approach the near optimum orbital capability and with the higher specific impulse.

FIG.1

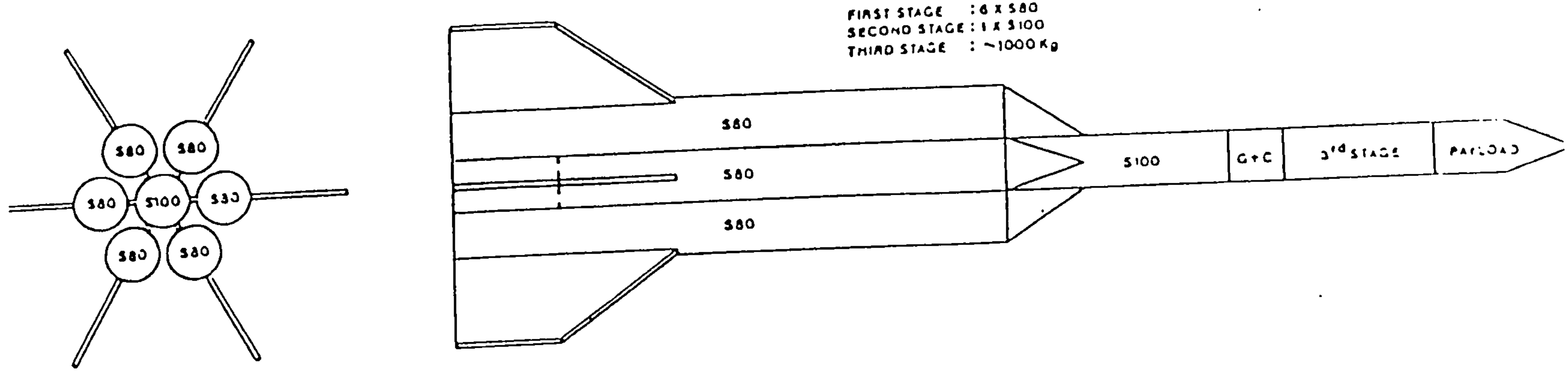


CONFIGURATION A
FIRST STAGE : 4 x S80
SECOND STAGE : 1 x S100
THIRD STAGE : ~1000 kg
S80
S80
S100
G+C
3rd STAGE
PAYLOAD
3·5
1·7
1·5
8·6
10·4
1·6
0.85
2.2
2.0
CONFIGURATION B
FIRST STAGE : 5 x S80
SECOND STAGE : 1 x S100
THIRD STAGE : ~1000 kg
S80
S100
G+C
3rd STAGE
PAYLOAD

FIG. 1 CONT.D

CONFIGURATION C

FIRST STAGE : 6 X S80
SECOND STAGE : 1 X S100
THIRD STAGE : ~1000 Kg



CONFIGURATION D

FIRST STAGE : 6 X S80
SECOND STAGE : 2 X S100
THIRD STAGE : ~1000 Kg